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PREDICTION and 3-D VISUALIZATION of REDOX in the CENTRAL VALLEY AQUIFER, CALIFORNIA

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CENTRAL VALLEY, CA

Background Information

- **Aquifer Lithology**
- **Population & Land Use**
- **Groundwater Use**
- **Groundwater Quality Concerns**

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Source: https://earthobservatory.nasa.gov

CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

Response Variables

6 REDOX MODELS:

Bernoulli Error Distribution – results in a model of predicted probabilites

3 Dissolved Oxygen Models	3 Manganese Models
Dissolved Oxygen event thresholds: ▪ < 0.5 mg/L ▪ < 1.0 mg/L ▪ < 2.0 mg/L	Manganese event thresholds: ▪ > 50 µg/L ▪ > 150 µg/L ▪ > 300 µg/L

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CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

Predictor Variables

66 predictor variables:

- Regional scale soil properties (*SSURGO*)
- Soil Chemistry (*Smith, et al., 2013*)
- Land use
- Aquifer Textures (*CVTM, Faunt et al. 2010*)
- Lateral Position (hydrologic position)
- Well Construction Information
- Predicted depth to water table-Spring 2000 (*CVHM, Faunt et al. 2010*)
- Vertical water flux (m^3/day) for irrigation and non-irrigation season (*CVHM, Faunt et al. 2010*)

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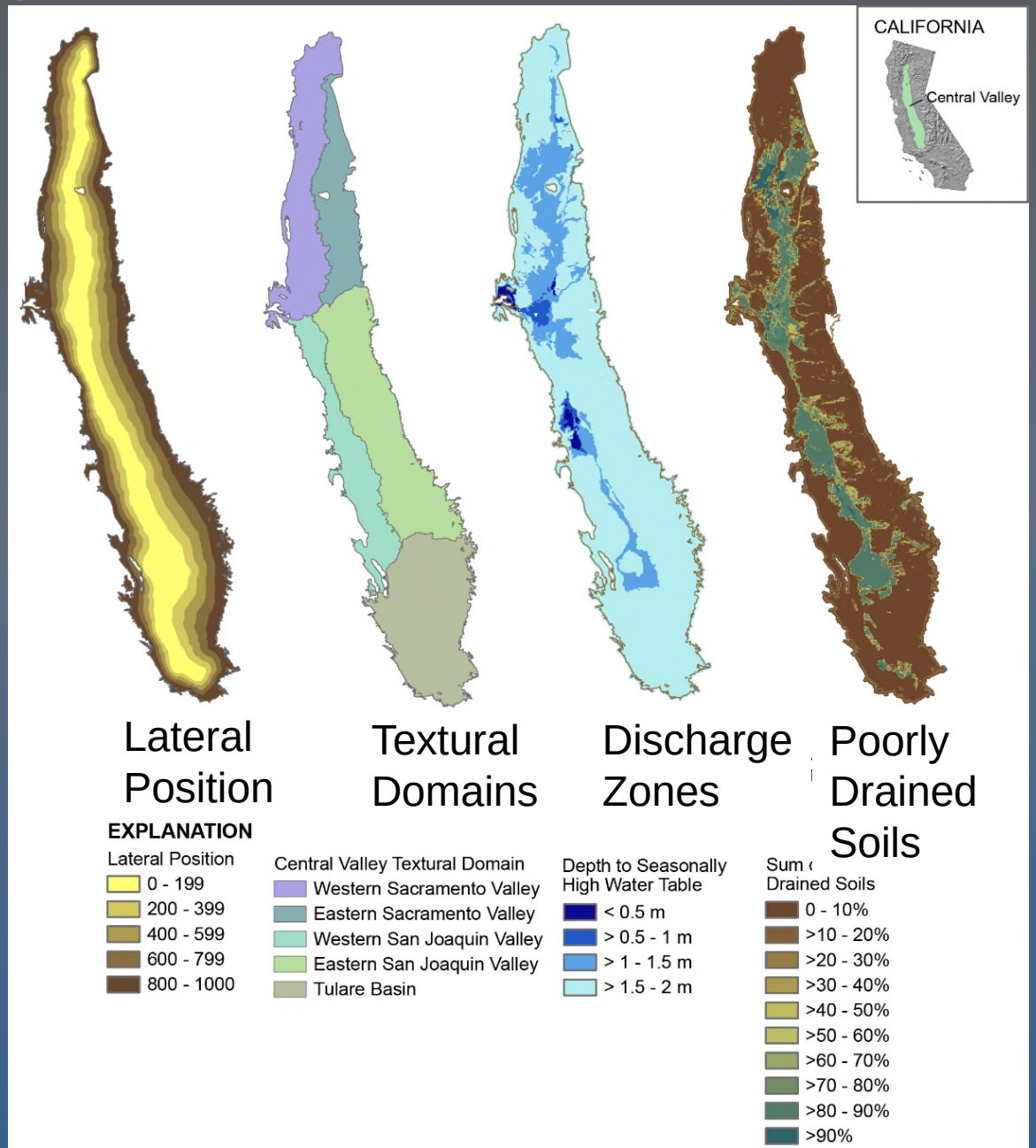
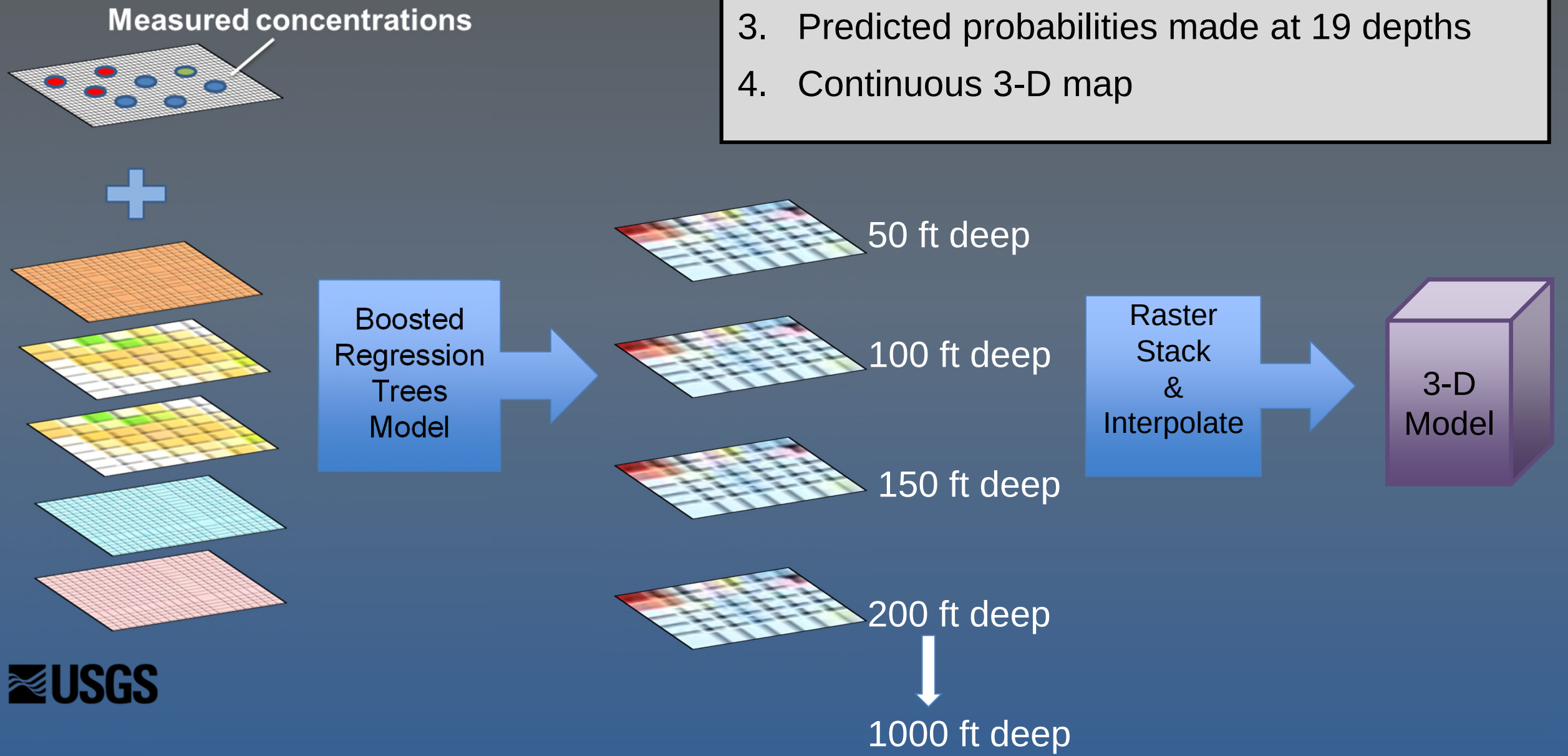


CENTRAL VALLEY, CA

Boosted Regression Trees Workflow

1. Predictor variables attributed to wells
2. Boosted regression tree modeling
3. Predicted probabilities made at 19 depths
4. Continuous 3-D map



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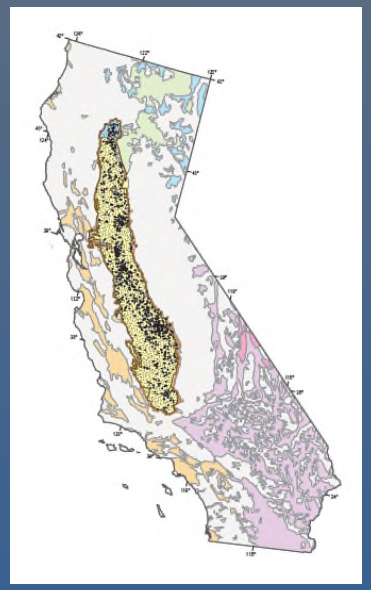
CENTRAL VALLEY, CA:

Boosted Regression Tree Models

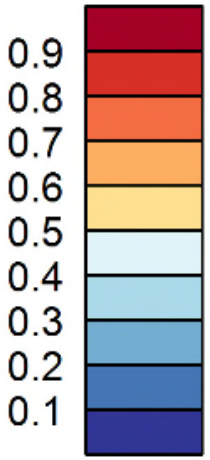
Model Results:

Predicted Dissolved Oxygen and Manganese Probabilities for selected thresholds at Domestic and Public Supply Depths

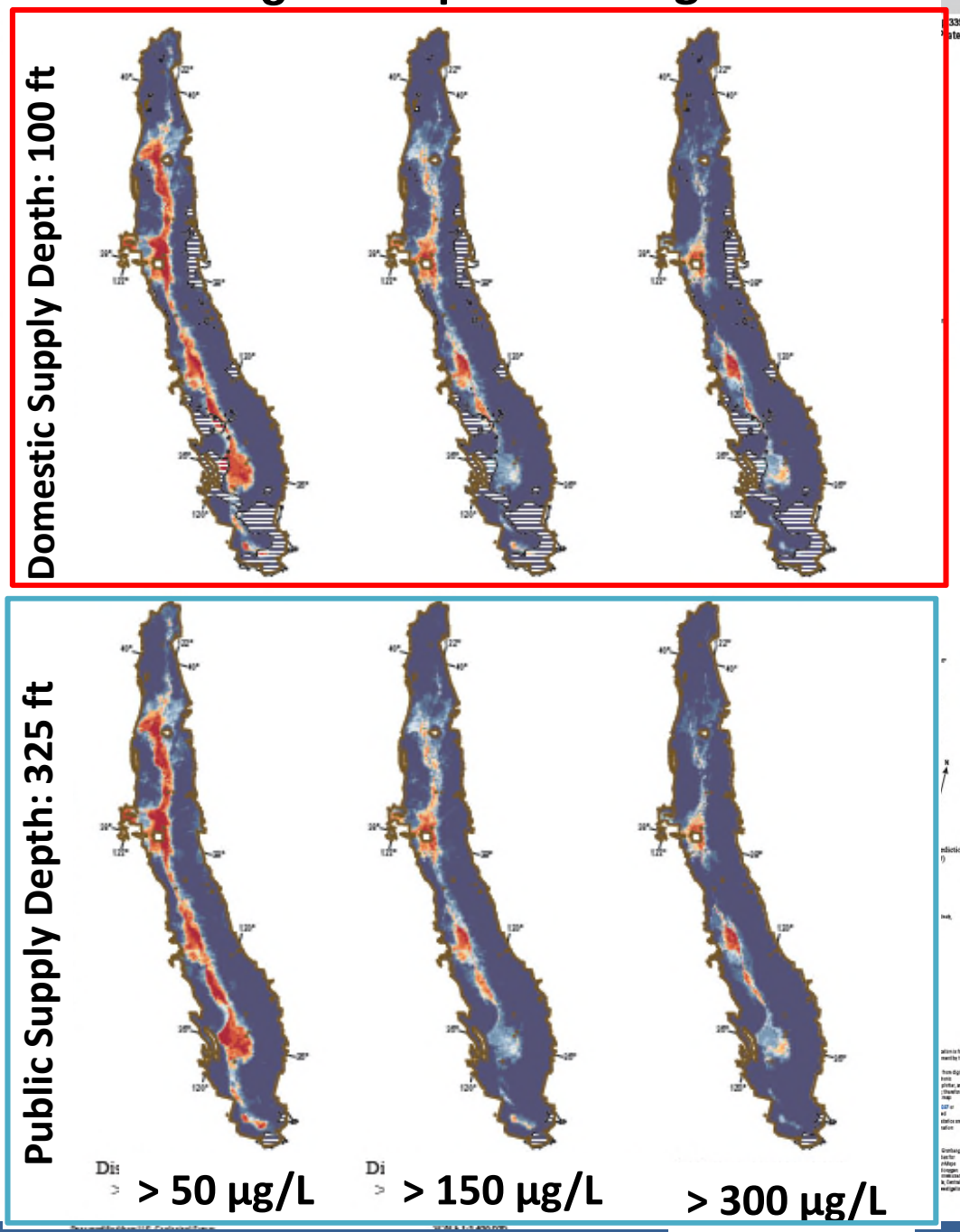
(USGS Scientific Investigations Map 3397: Rosecrans et al., 2018)



Probability of event

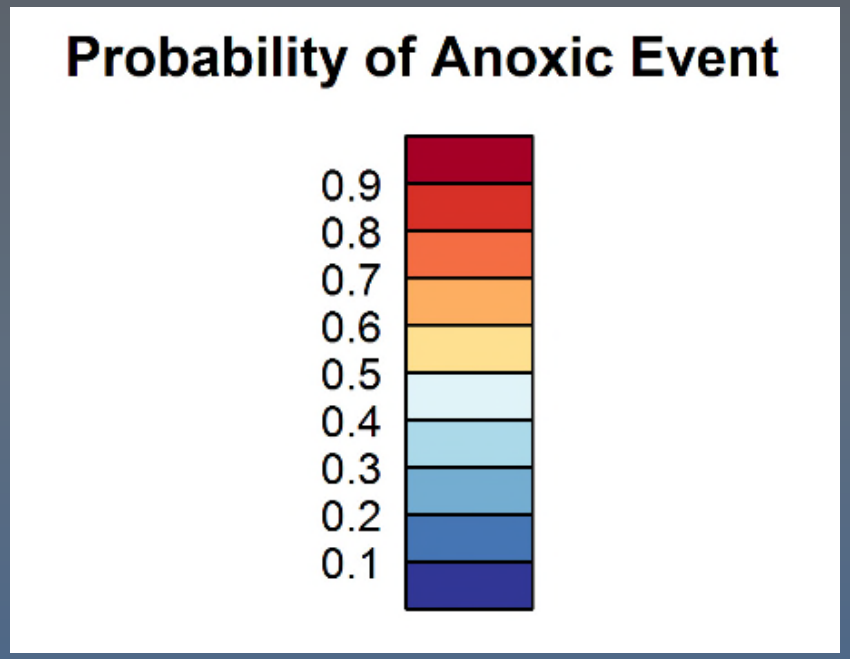


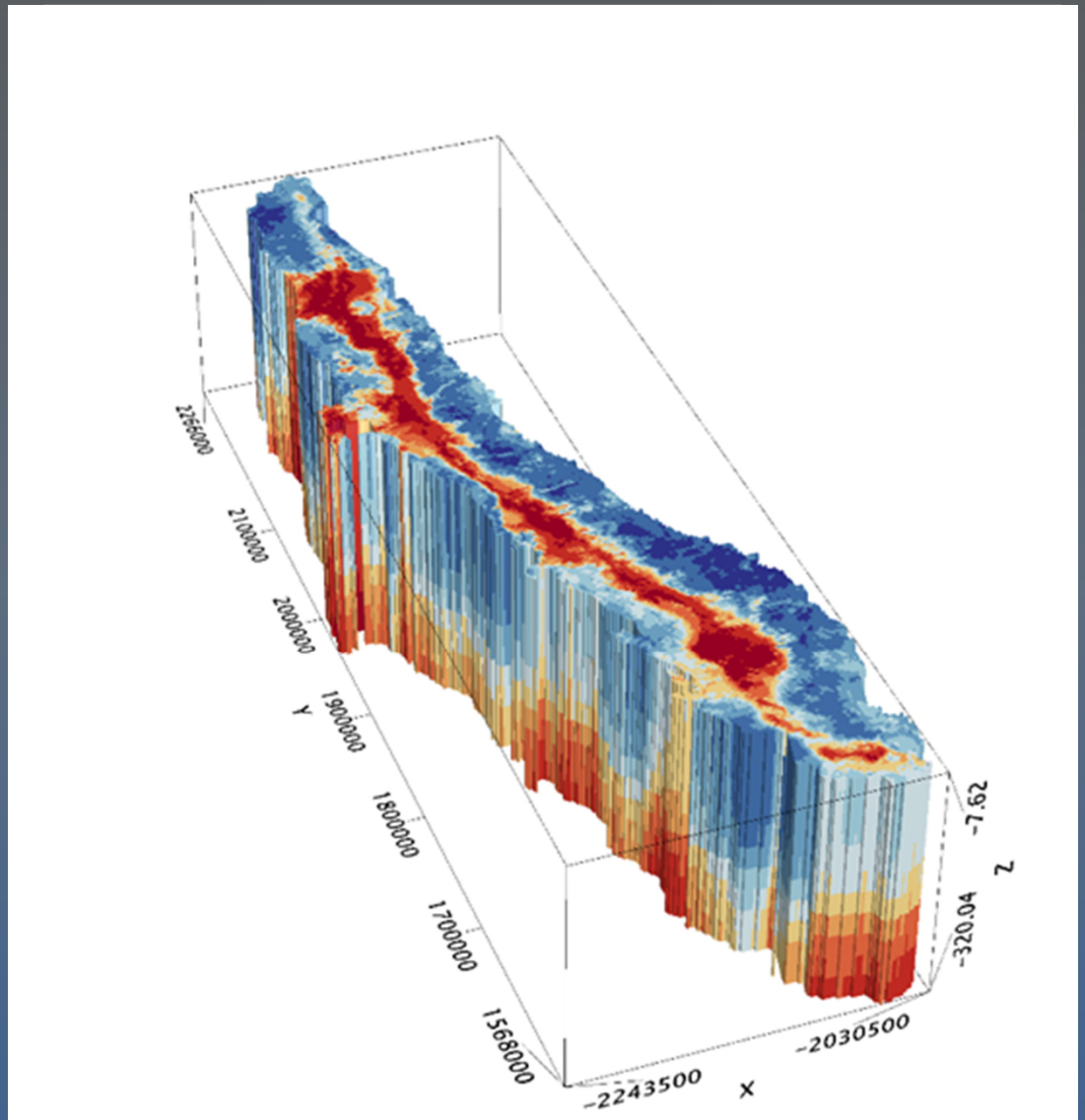
Manganese prediction grids



CENTRAL VALLEY, CA: *Prediction Grids to Continuous 3-D model*

Model Results





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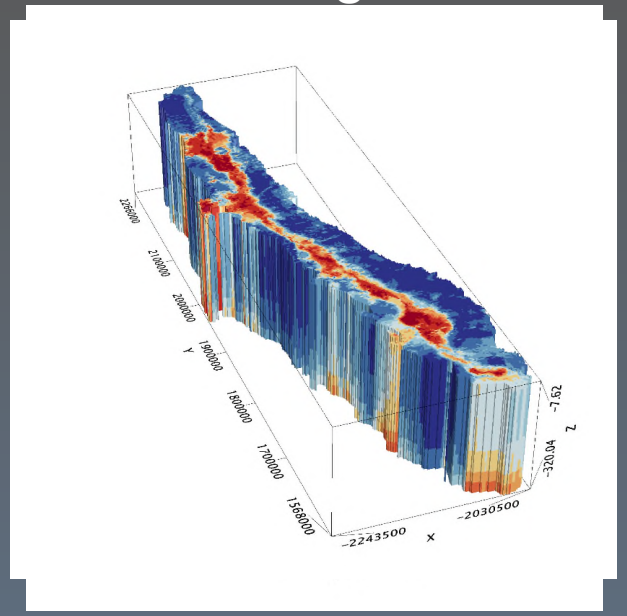
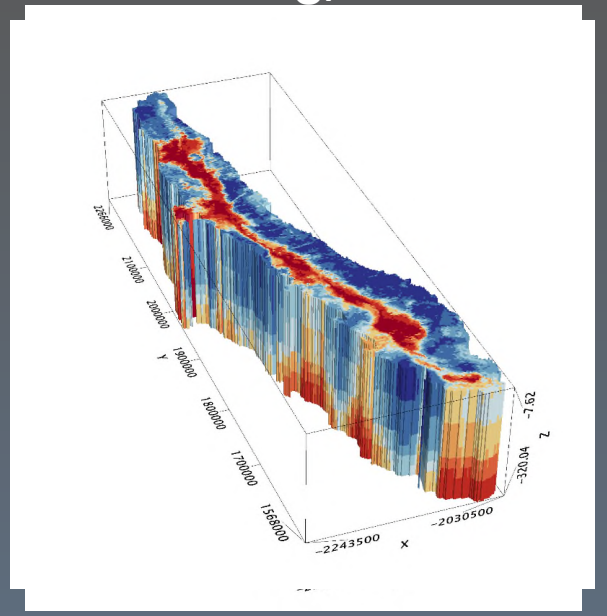
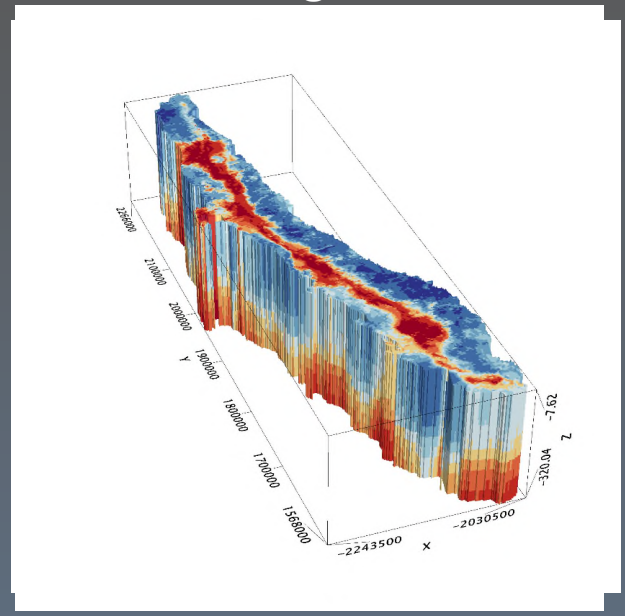
DO < 0.5 mg/L threshold



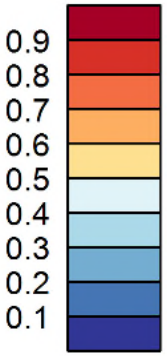
DO < 1.0 mg/L threshold



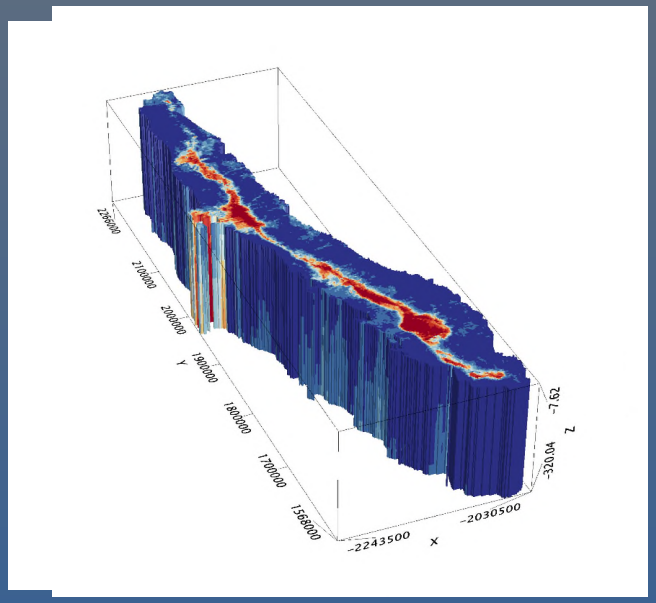
DO < 2.0 mg/L threshold



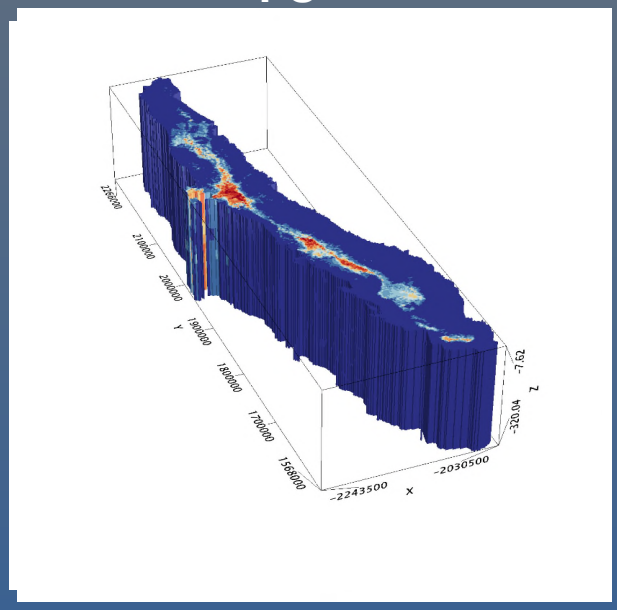
Probability of event



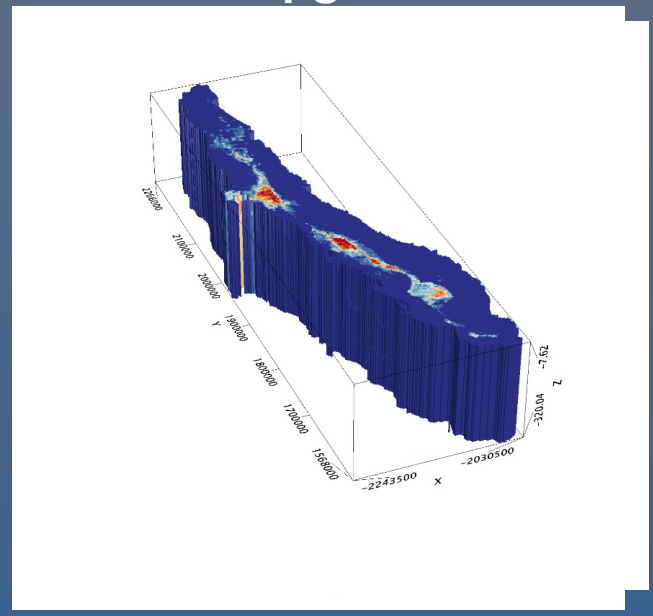
Mn > 50 µg/L threshold



Mn > 150 µg/L threshold



Mn > 300 µg/L threshold



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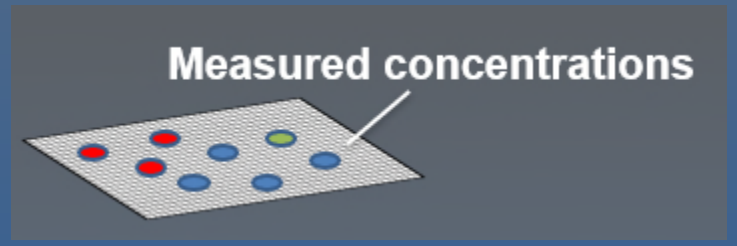
CENTRAL VALLEY, CA:

Application of Redox Predictions Grids to Central Valley Nitrate Model:

- Central Valley DO and Mn probabilities were used as predictor variables in the **Central Valley Nitrate model** *(Ransom et al., 2017)*
- Over 5000 wells with measured nitrate (mg/L as N)
- Gaussian Error Distribution: predictions are continuous



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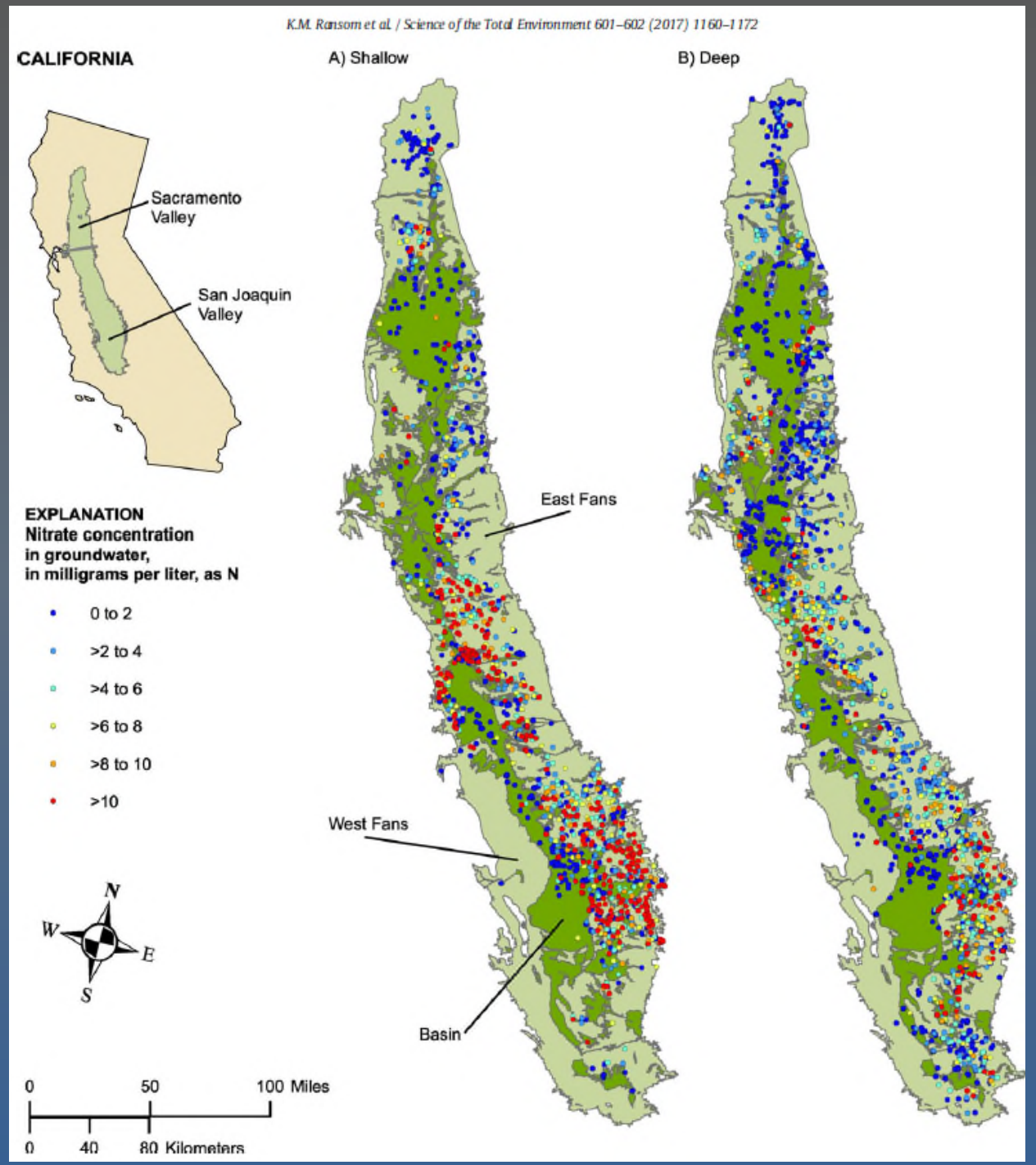
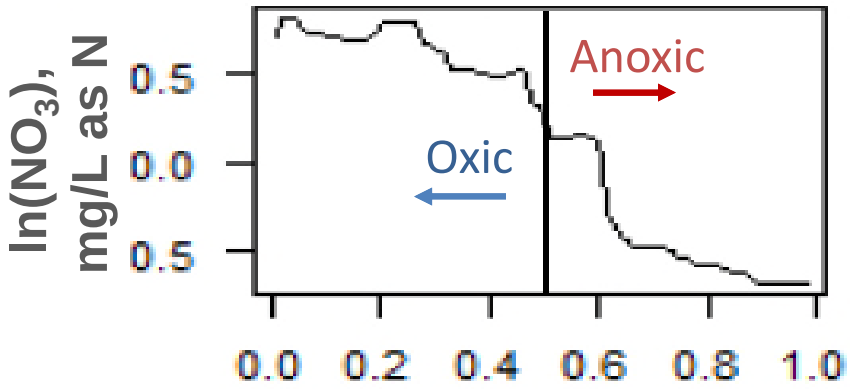
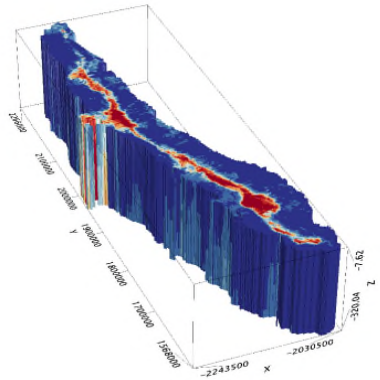


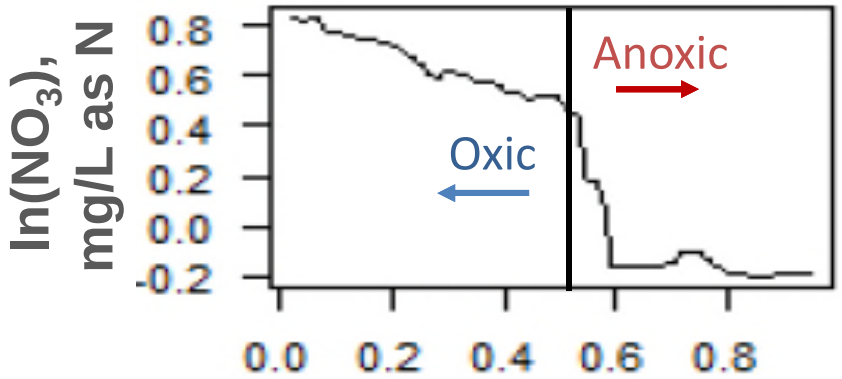
CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

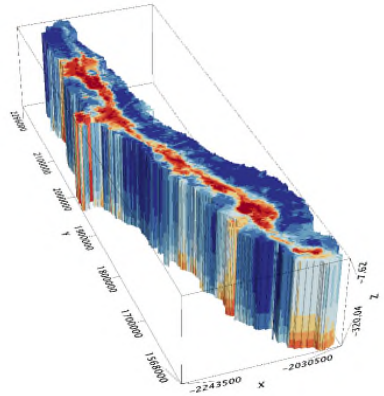
Application of Redox Predictions Grids:





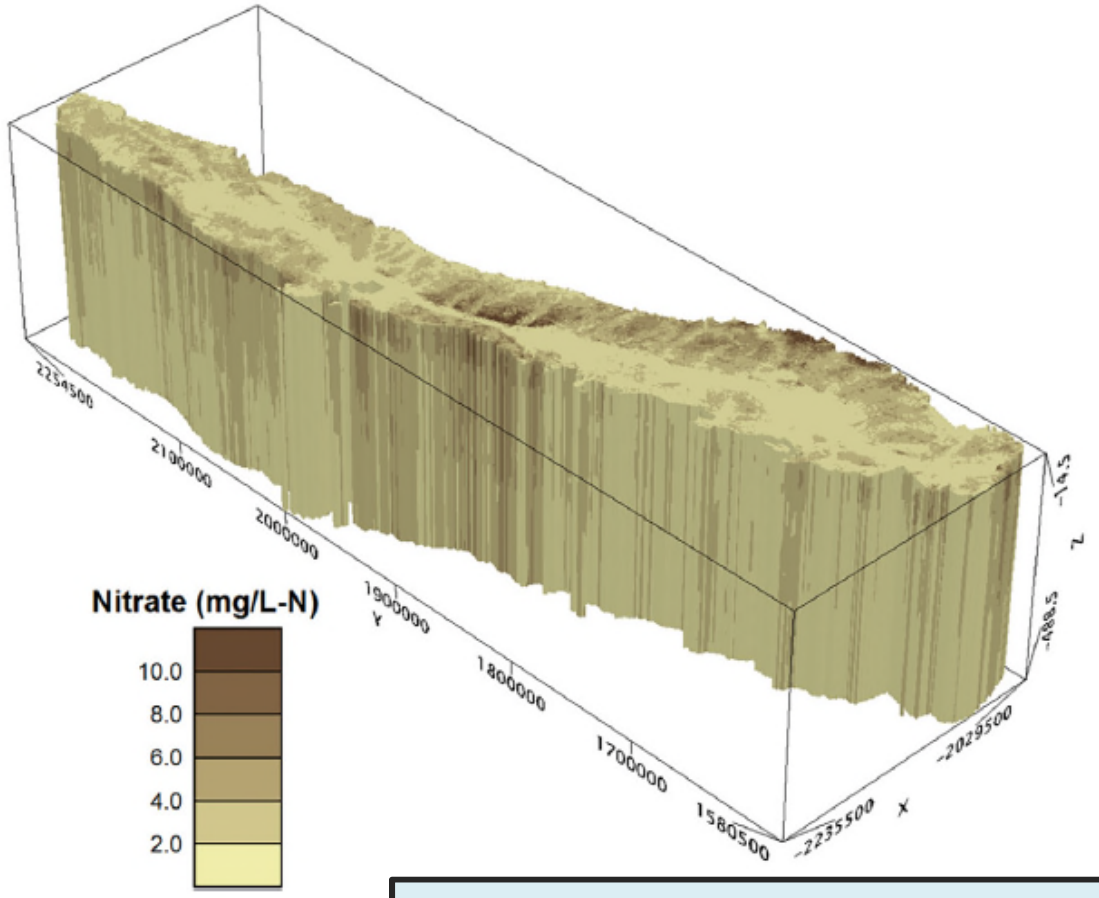
1. Manganese (> 50 µg/L) Probability





2. Dissolved Oxygen (< 0.5 mg/L) Probability

Ransom et al, 2017; Science of the Total Environment 601-602



Training R^2 0.83; RMSE 0.705
Holdout R^2: 0.44; RMSE 1.132

Thank you.

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References:

Faunt, C.C., Belitz, K., Hanson, R.T., 2010. Development of a three-dimensional model of sedimentary texture in valley-fill deposits of Central Valley, California, USA. Hydrogeol. J. 18, 625–649.

Faunt, C.C., 2009. Groundwater availability in the Central Valley aquifer, California. U.S. Geological Survey Professional Paper 1776.

Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L., 2013, Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801.

Ransom, K.M., Nolan, B.T., Traum, J.A., Faunt, C.C., Bell, A.M., Gronberg, J.M., Wheeler, D.C., Jurgens, B., Schwartz, G.E., Belitz, K., Eberts, S.M., Kourakas, G., Harter, T., 2017, A hybrid machine learning model to predict and visualize nitrate concentration throughout the Central Valley aquifer, California, USA: Science of the Total Environment, pp. 1160-1172

Rosecrans, C.Z., Nolan, B.T., and Gronberg, J.M., 2017, Prediction and visualization of redox conditions in the groundwater of Central Valley, California: Journal of Hydrology, 546, pp. 341-356, http://dx.doi.org/10.1016/j.jhydrol.2017.01.014

Rosecrans, C.Z., Nolan, B.T., and Gronberg, J.M., 2017, Ascii grids of predicted pH in depth zones used by domestic and public drinking water supply depths, Central Valley, California: U.S. Geological Survey data release, https://doi.org/10.5066/F7FX77K4.

Rosecrans, C.Z., Nolan, B.T., and Gronberg, J.M., 2018, Probability distribution grids of dissolved oxygen and dissolved manganese concentrations at selected thresholds in drinking water depth zones, Central Valley, California: U.S. Geological Survey data release, https://doi.org/10.5066/F7T151S1

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CENTRAL VALLEY, CA:

Boosted Regression Trees Models

Model Results:

pH Model at Domestic and Public Supply Depths

(USGS Scientific Investigations Map 3377: Rosecrans et al., 2017)

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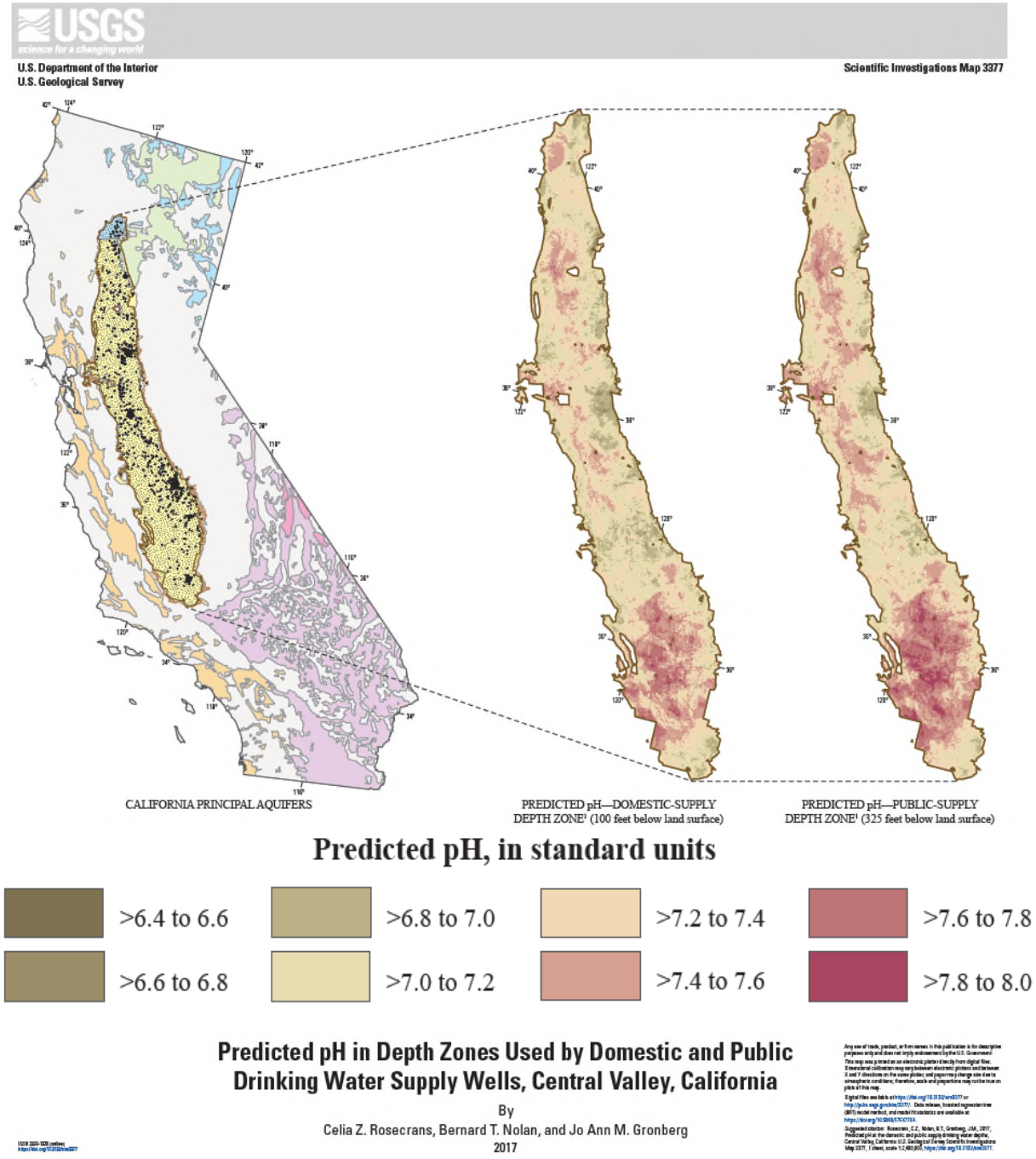
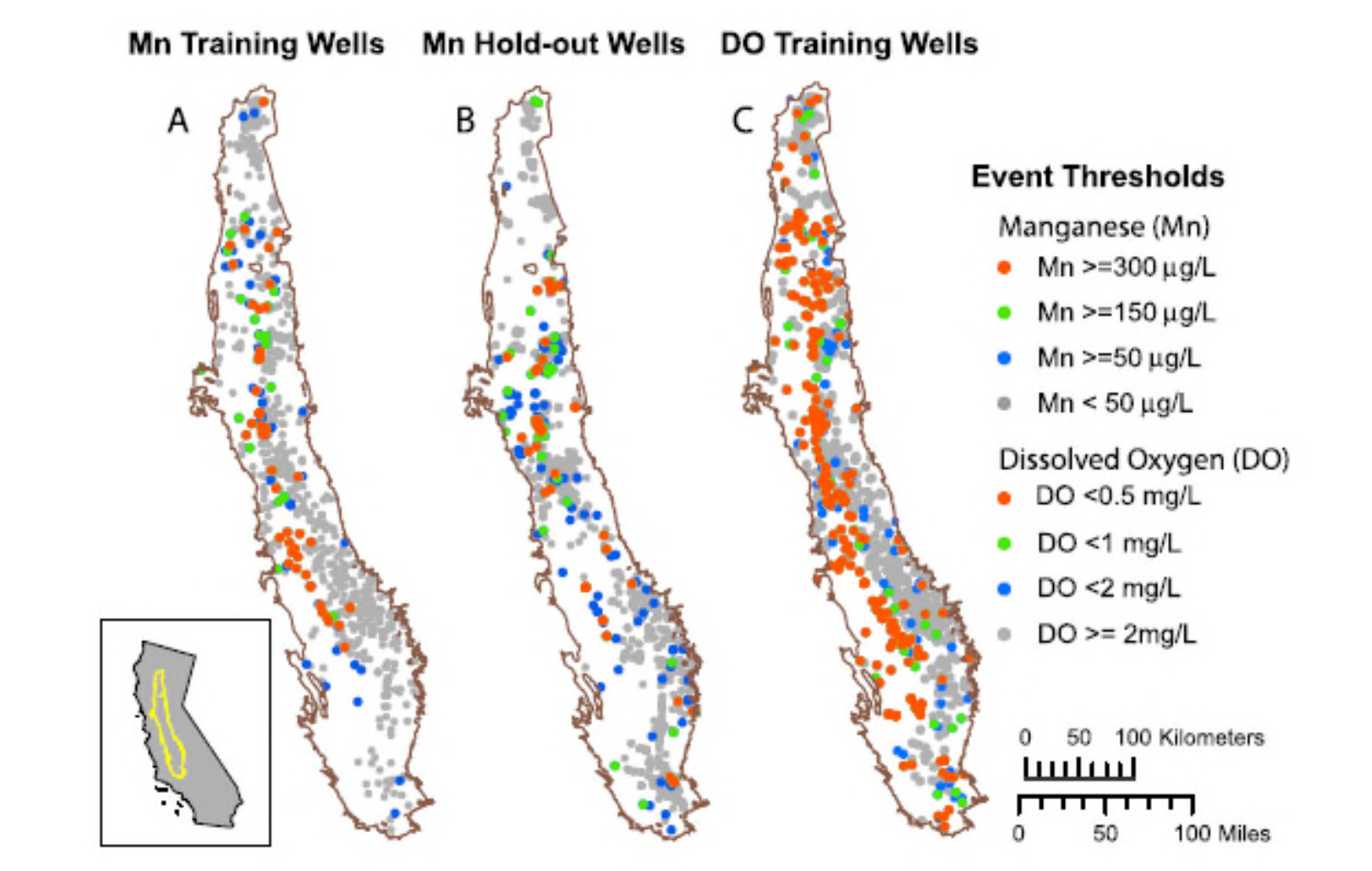


CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

Response Variables

REDOX MODELS: Event threshold distribution



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CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

Model Evaluation

1. ***Model Metrics:***
    - **KAPPA**
    - **ACCURACY**
    - **ROC CURVE (receiver operator characteristic curve)**
2. ***Predictor Variable Ranking:*** **ranking of influence of all predictor variables for a given response variable**
3. ***Partial Dependency Plots:*** **indicate the direction of influence and show effects of a single variable on a predicted response**

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CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

Model Fit Results for Disssolved Oxygen models:

Event Threshold	Model	Accuracy	KAPPA	ROC	Events
Dissolved Oxygen <0.5 mg/L	Training	89%	0.71	0.94	***n= 251***
	Cross-Validation Testing	***84%***	***0.57***	***0.88***	
Dissolved Oxygen <1.0 mg/L	Training	88%	0.71	0.94	***n=306***
	Cross-Validation Testing	***86%***	***0.66***	***0.90***	
Dissolved Oxygen <2.0 mg/L	Training	86%	0.73	0.92	***n=371***
	Cross-Validation Testing	***82%***	***0.62***	***0.87***	

CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

Model Fit Results for Mn models:

Event Threshold	Model	Accuracy	KAPPA	ROC	Events
Manganese: < 50 µg/L	Training (n=812)	99%	0.80	0.99	n=135
	Holdout (n=1835)	***89%***	***0.29***	***0.75***	***n=212***
Manganese: < 150 µg/L	Training (n=812)	96%	0.72	0.98	n=79
	Holdout (n=1835)	***94%***	***0.12***	***0.74***	***n=103***
Manganese: < 300 µg/L	Training (n=812)	97%	0.68	0.97	n=55
	Holdout (n=1835)	***96%***	***0.12***	***0.73***	***n=52***

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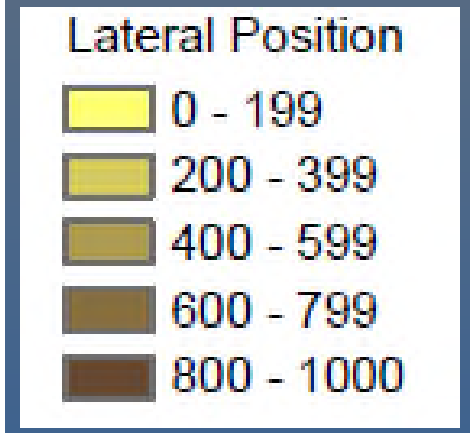
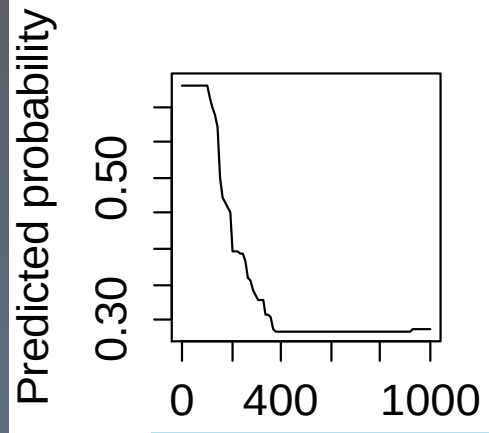
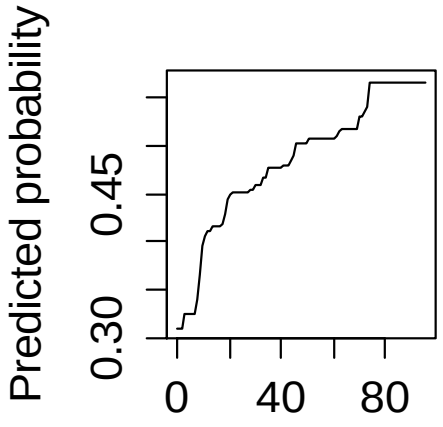
CENTRAL VALLEY, CA: *Boosted Regression Tree Models*

Partial Dependency Plots and Predictor Variable Ranking (DO < 2.0 mg/L):

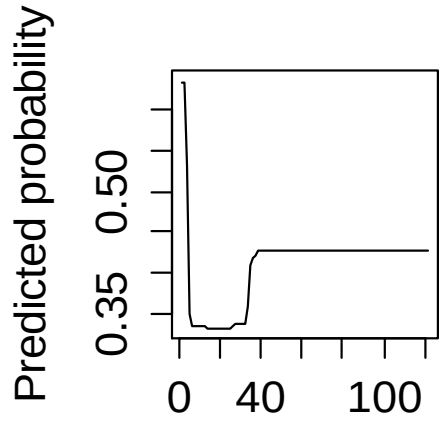




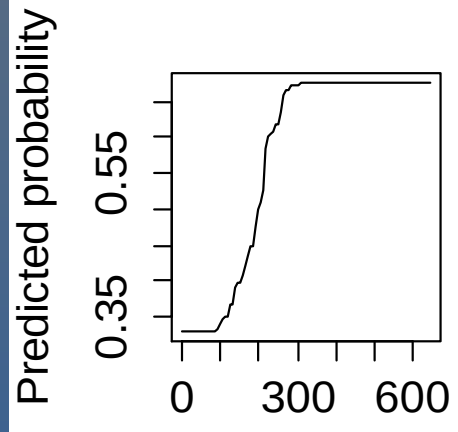
1. Lateral Position



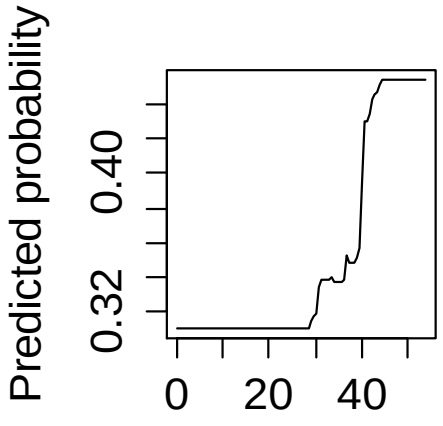
2. Poorly Drained Soils, percent



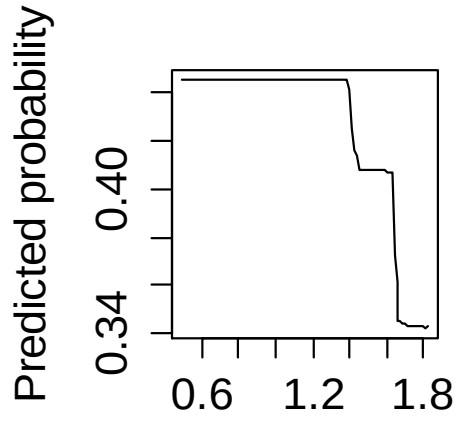
3. Spring 2000 Depth to WT



4. Well Depth



5. Ave. Porosity, percent



6. Depth to WT, m